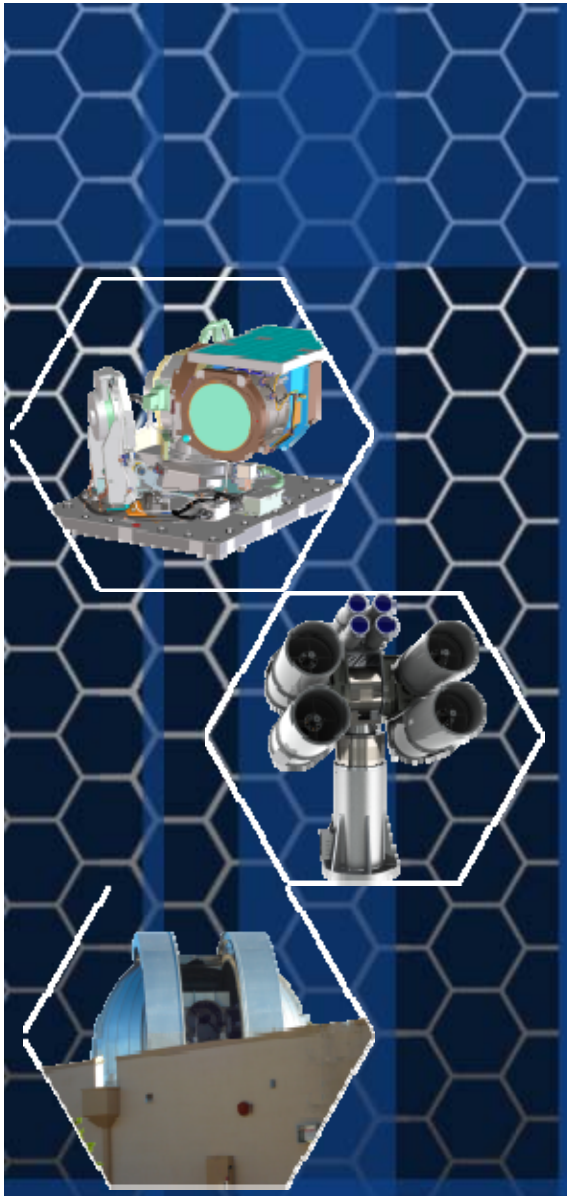
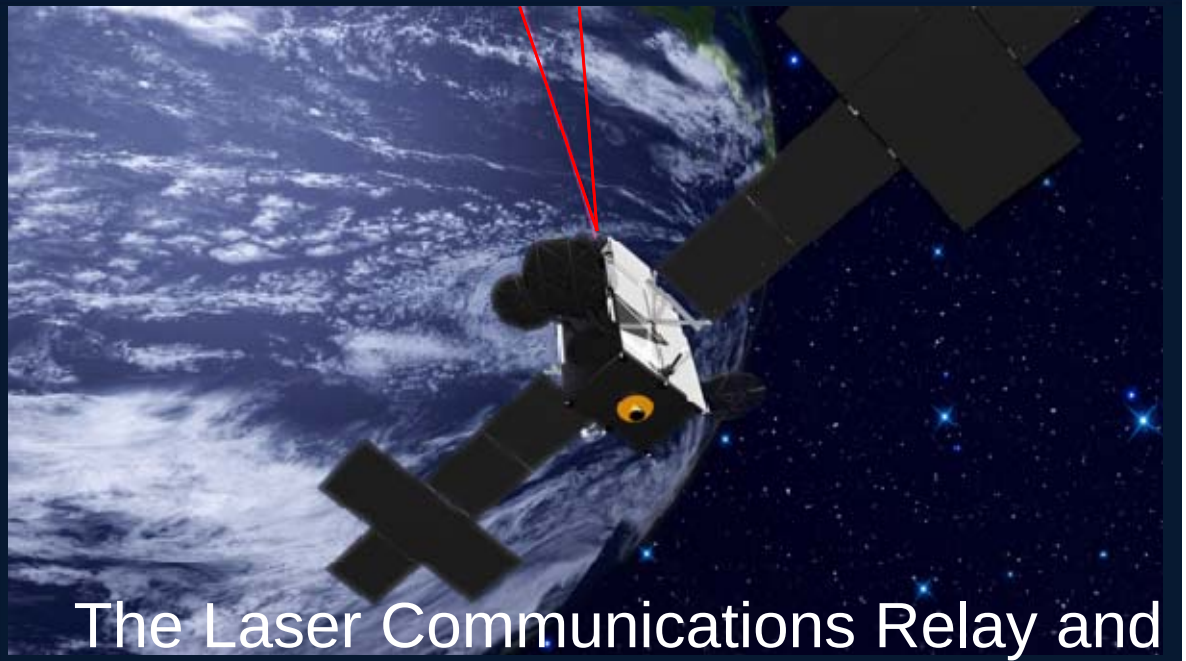


LASER COMMUNICATIONS RELAY DEMONSTRATION

National Aeronautics and Space Administration



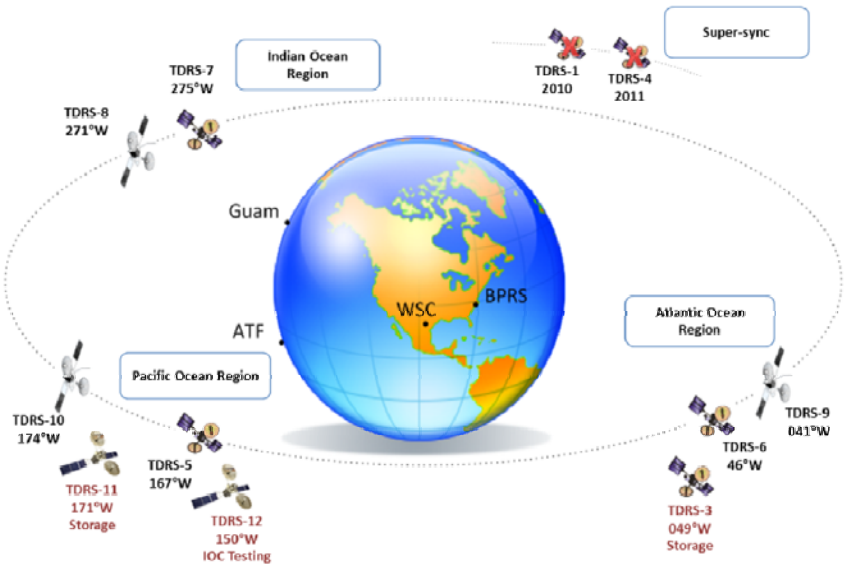
The Laser Communications Relay and the Path to the Next Generation Near Earth Relay

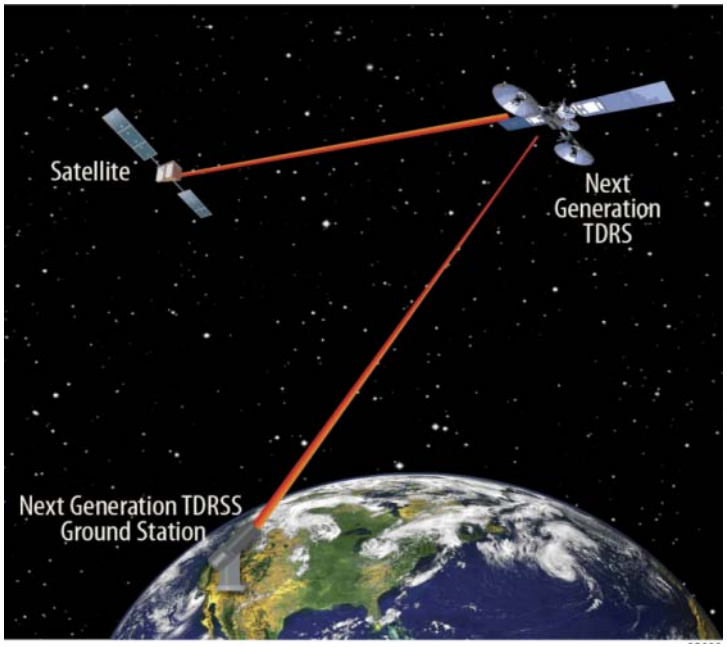
David J. Israel
NASA/GSFC

May 20, 2015

Goddard JPL GSSL

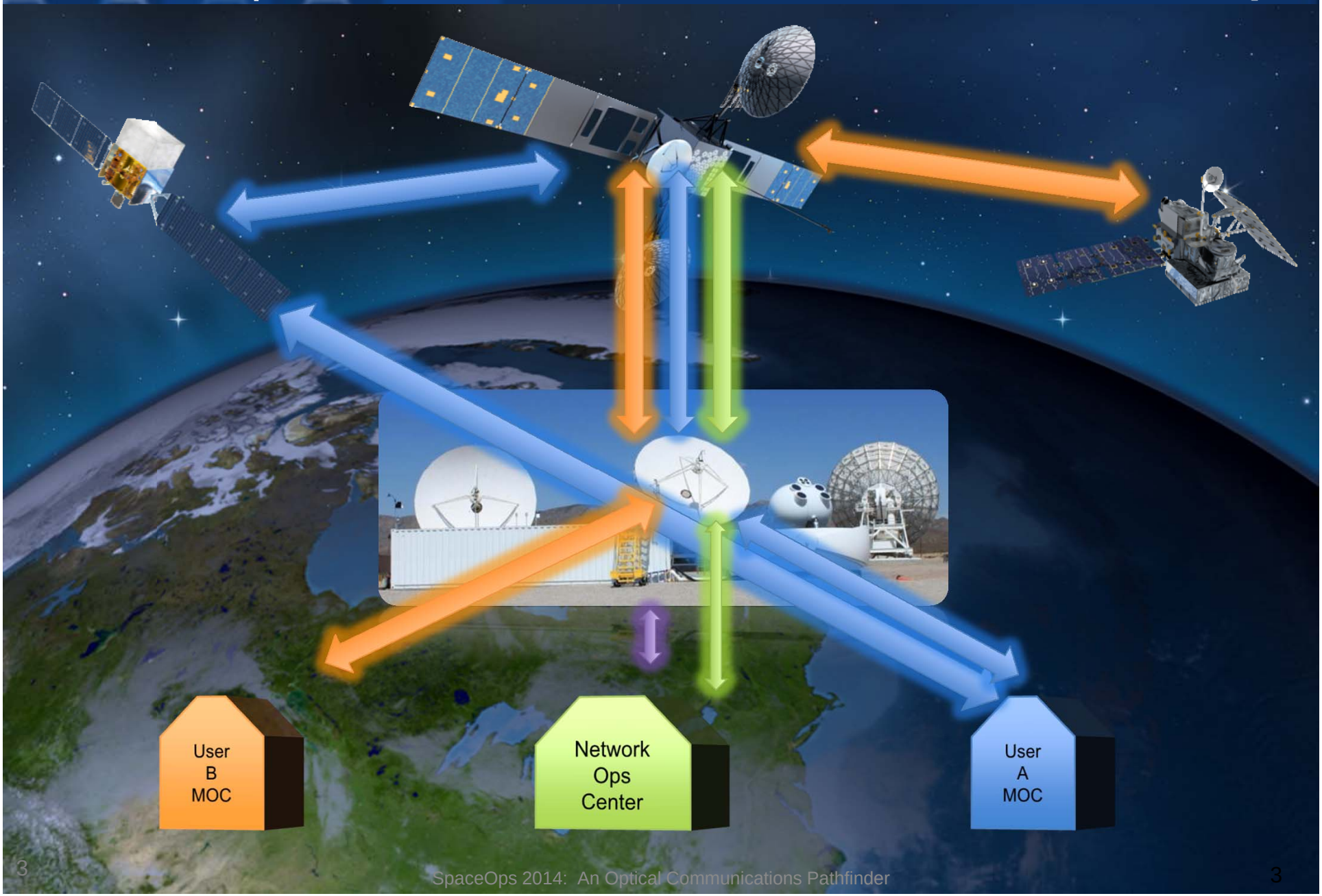
Introduction



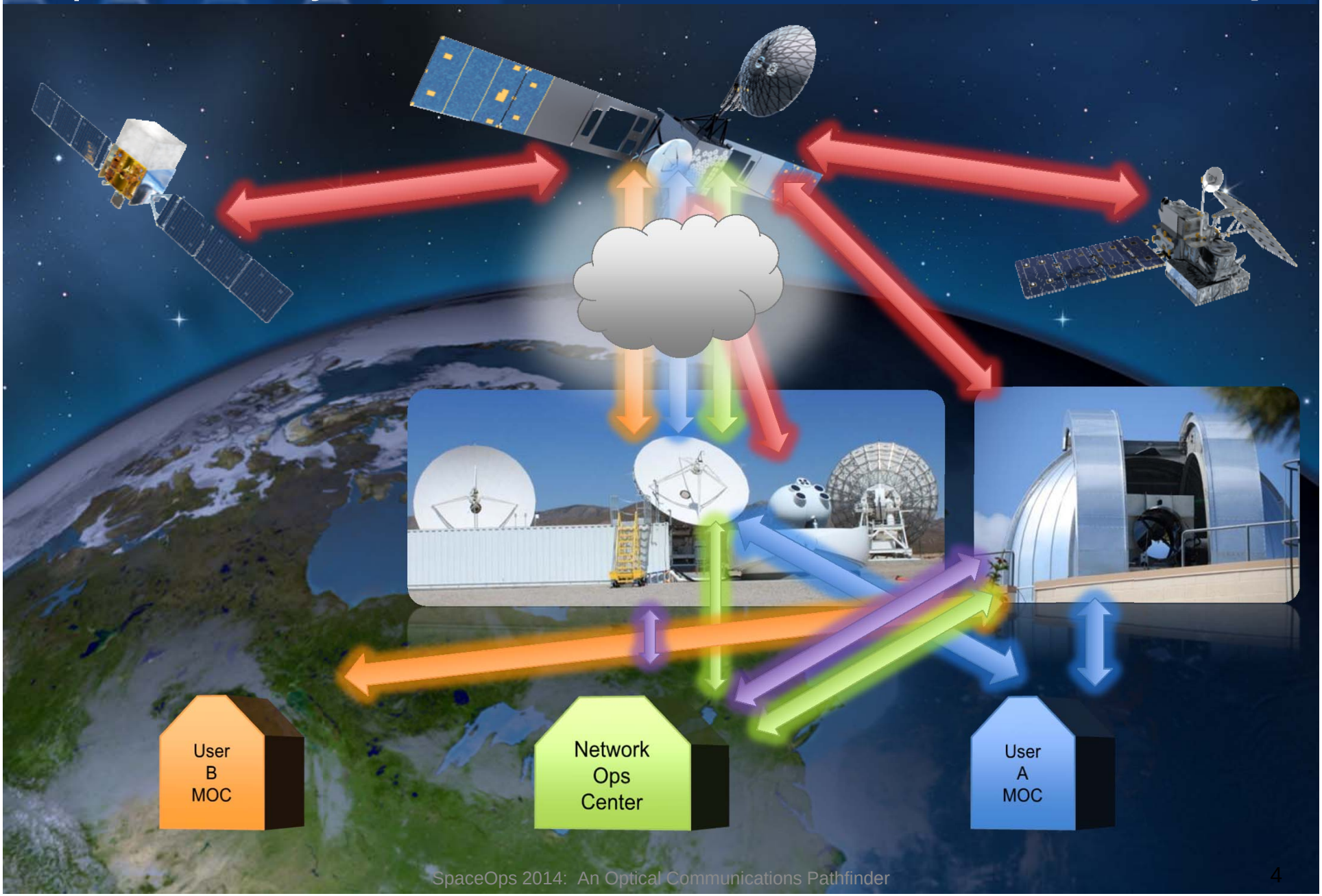


- The NASA Space Network or Tracking and Data Relay Satellite System is comprised of a constellation of Tracking and Data Relay Satellites (TDRS) in geosynchronous orbit and associated ground stations and operation centers.
- NASA is currently targeting a next generation of relay capability on orbit in the 2025 timeframe.

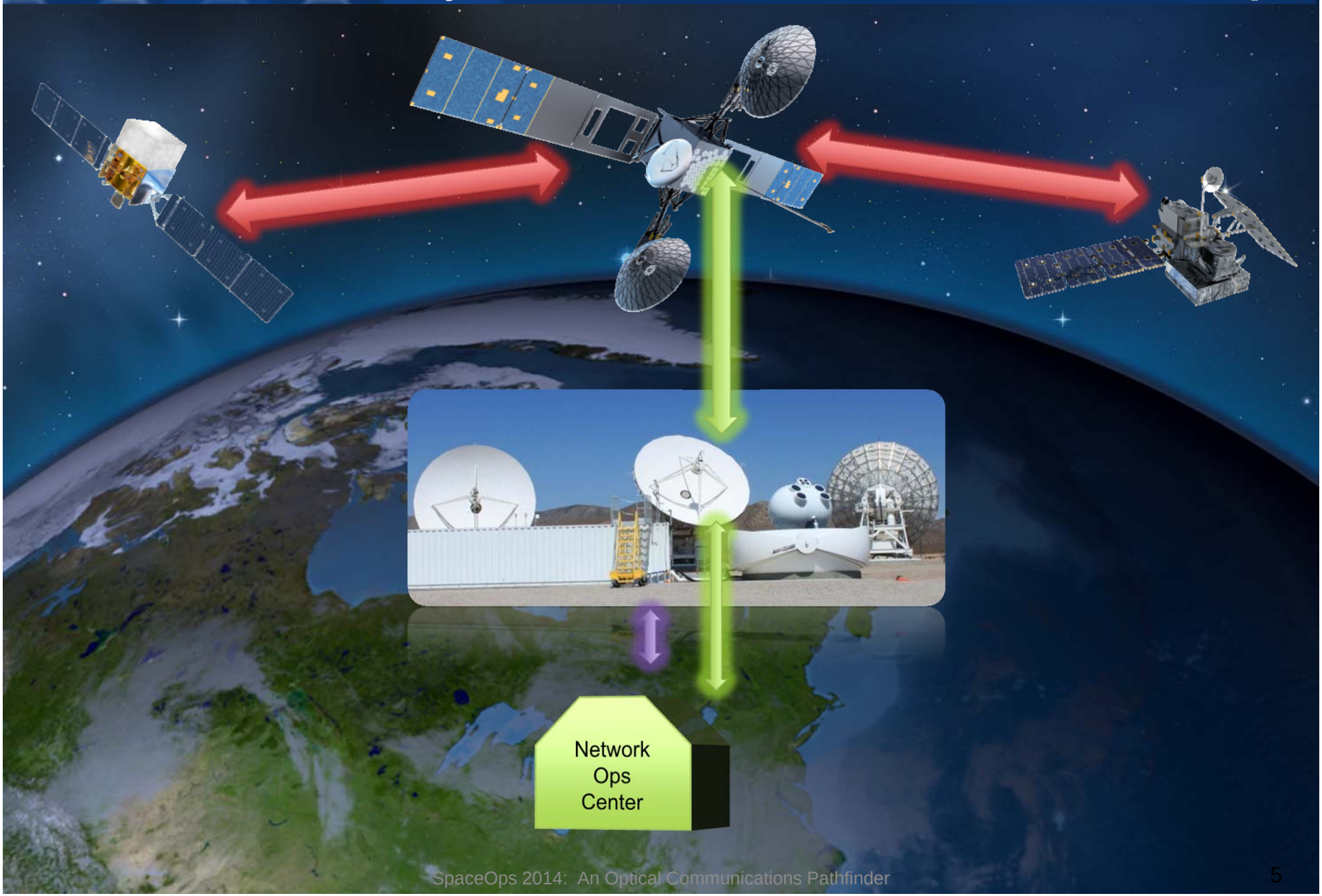
Current Space Network Architecture



Optical Relay Architecture



User-to-User Relay Services



Mission Architecture

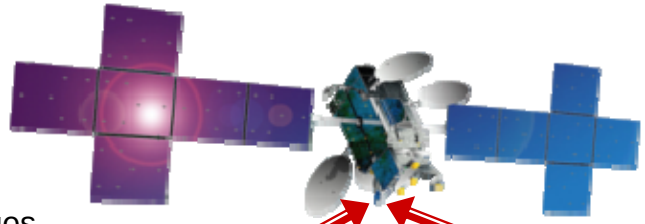
Remaining Challenges for an Optical TDRSS

- If an operational relay network were to include an optical space-to-ground link or trunkline, how could the network meet user availability requirements with the impact of clouds and atmosphere?
  - Multiple ground stations and/or crosslinks
  - Hybrid RF and Optical trunklines
  - Routing, prioritizing, and rate-buffering user data streams using DTN protocols
- Dedicated relay spacecraft or hosted payload?

Laser Communications Relay Demonstration Mission Architecture

LCRD

LCRD Payload and Host Spacecraft



LCRD Flight Payload
2 Optical Relay Terminals
- **10.8 cm aperture**
- **0.5 W transmitter**
- **DPSK and PPM**

Space Switching Unit

Relay Link Features:
- Coding/Interleaving at the link edges
  - Rate ½ DVB-S2 codec (LDPC)
  - 1 second of interleaving for atmospheric fading mitigation

1244 Mbps DPSK
311 Mbps 16-PPM

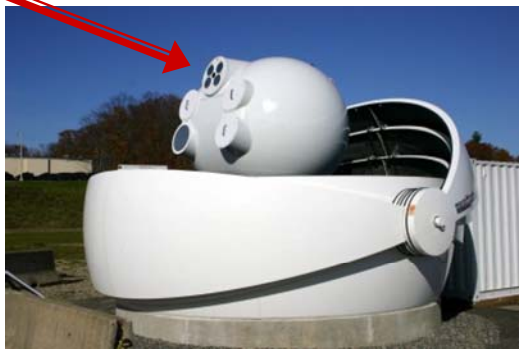
1244 Mbps DPSK
311 Mbps 16-PPM

Table Mountain, CA

LCRD Ground Station 1
1 m transmit and receive aperture
- **20 W transmitter**

Mission Concept

- Orbit: Geosynchronous
  - Longitude TBD between 162ºW to 63ºW
- 2 years mission operations / 5 years goal
- 2 operational GEO Optical Relay Terminals
- 2 operational Optical Earth Terminals
- Optical relay services provided
  - Ability to support a LEO User
  - Potential ISS demonstration
- Hosted Payload
- Launch Date: 2019



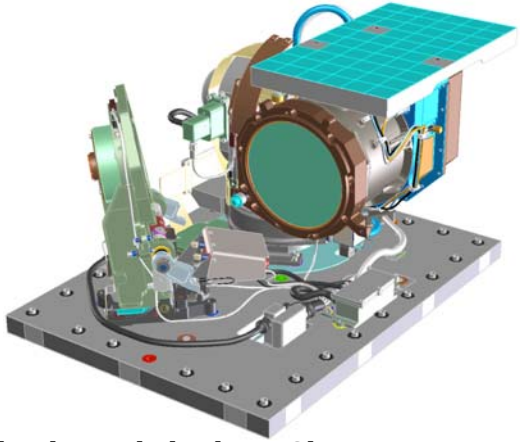
White Sands, NM

LCRD Ground Station 2
15 cm transmit aperture
- **20 W transmitter**

40 cm receive aperture

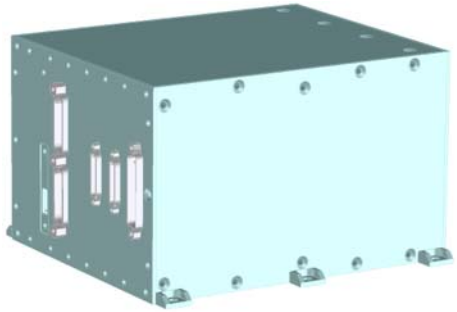
8

LCRD Payload Hardware Overview



Optical Module (qty 2)

- Gimbaled telescope (elevation over azimuth)
  - 12° half-angle Field of Regard
- 10.8 cm aperture, 14 kg
- Local inertial sensor stabilization

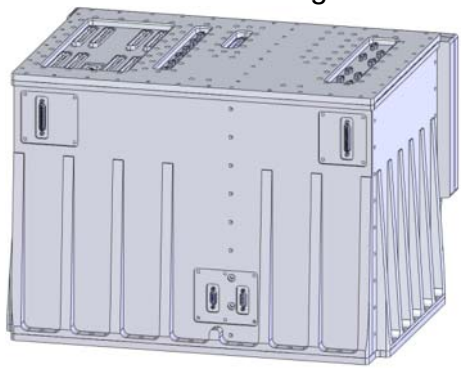


Controller Electronics (CE) (qty 2)

- OM control/monitoring
- Interface to Host Spacecraft
- 7 kg, 151 W

Integrated Modem (qty 2)

- 0.5 W transmitter; optically pre-amplified receiver
- DPSK and PPM modulation
- 27 kg, 130 W
- Supports Tx and Rx frame processing
  - No on-board coding and interleaving



Space Switching Unit (qty 1)

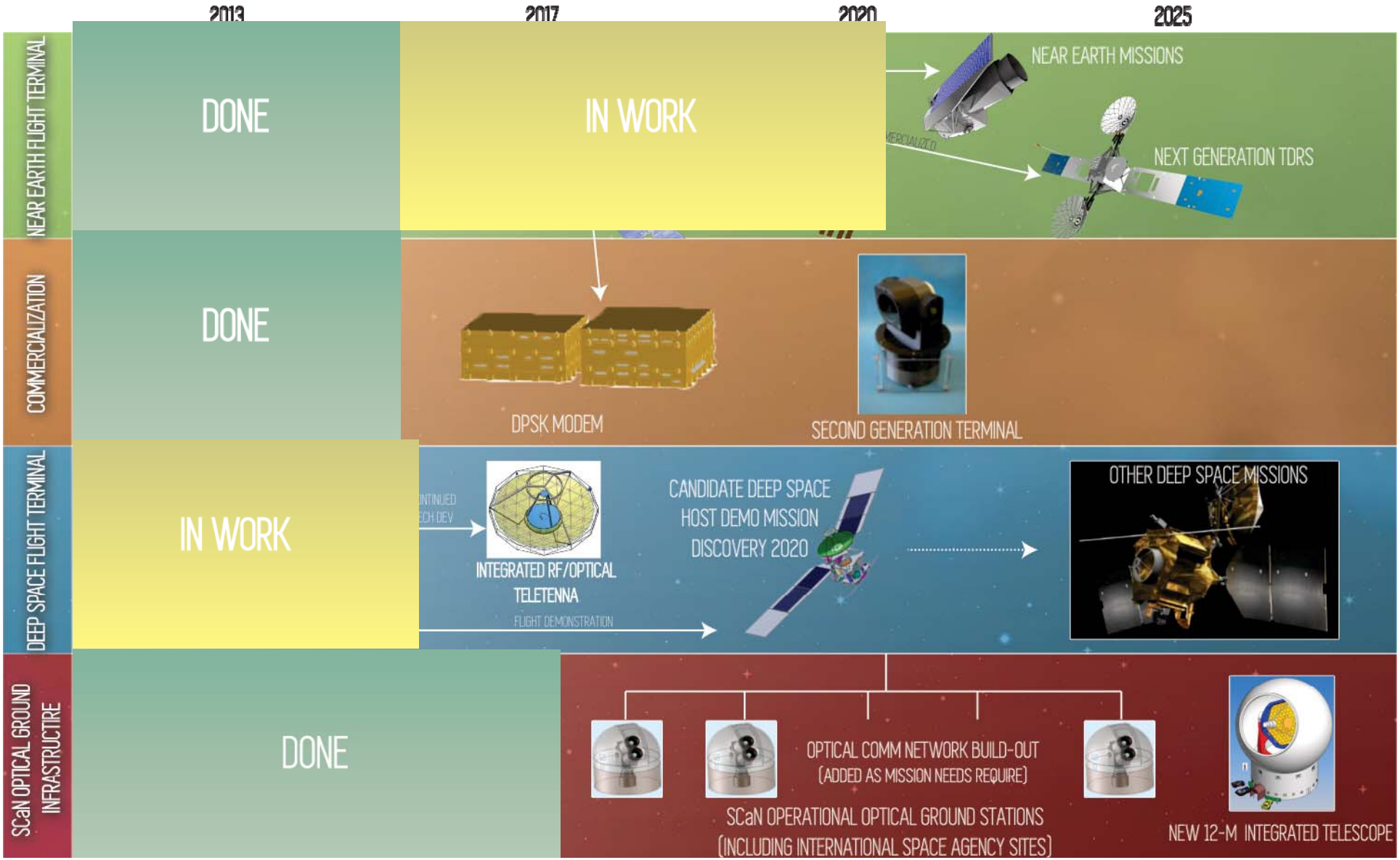
- Flexible interconnect between modems to support independent communication links
  - High speed frame switching/routing
- Command and telemetry processor

Anticipated LCRD Products

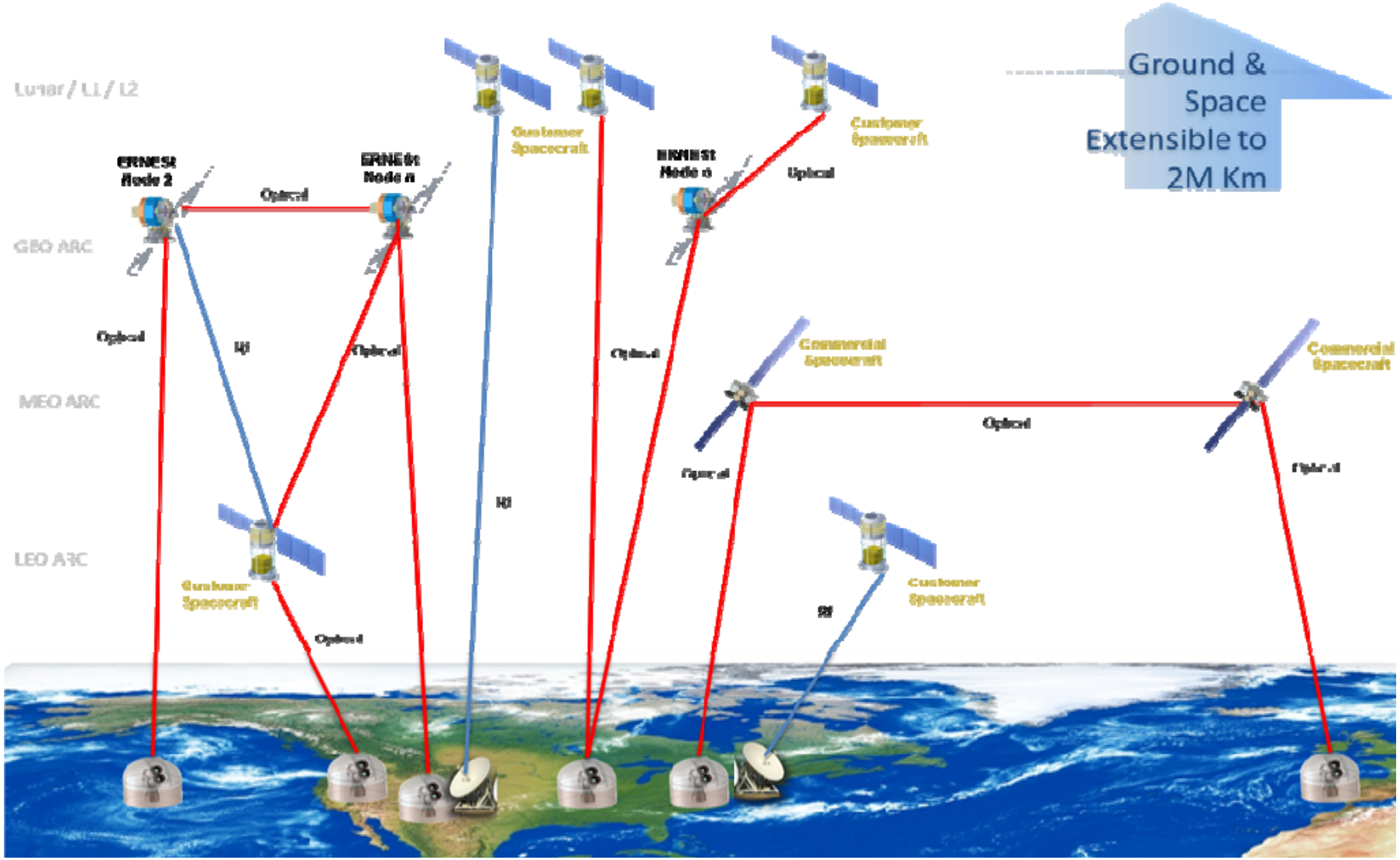
- Understanding of necessary requirements for future NASA systems
  - Resolution of Future System TBD/TBRs
  - Data for trade studies
  - Optimized operational procedures
- Demonstration of ability to procure, integrate, test, and operate space optical communications hardware
- Demonstration of NASA development of optical communications systems based MIT LL designs
- NASA owned and operated optical communications ground systems and network operations center
- Atmospheric measurements and model development
- Link performance measurements and model development
- Flight hardware performance characterization and flight hours
- Demonstration of optical communications benefits for a variety of mission scenarios

SCaN Optical Communication Technology Development & Infusion Mission Roadmap

LCRD



Space Mobile Network 2040



Conclusion

- LCRD will address key remaining questions beyond “will optical communications work?” and a wealth of data will be available for the development and deployment of future systems
- Future users and providers of optical communications services will also be able to see an operational system, in order to understand how the services will enable their missions
- The NASA experience in procuring, integrating, testing, and operating the flight terminal will inform the procurement activities of future systems
  - NASA will be more capable to develop the specifications and manage system deliveries
  - The technology, knowledge, and experience will all be shared with Industry and will improve the design proposals
- Hosted payload experience will benefit both NASA and commercial operators
- NASA continues to progress toward a future Near Earth Architecture